OXYURIS-LARVÆ HATCHED IN THE HUMAN STOMACH UNDER NORMAL CONDITIONS.

By N. A. Cobb.

(Plate VIII.)

In spite of the fact that Oxyuris vermicularis, the common pinworm or thread-worm parasitic in man, is the Nematode that has been longest known and is the one that comes most frequently under the notice of physicians and helminthologists, its life-history has remained incompletely solved. In this respect it is simply illustrative of nearly all the entozoa inhabiting man. It is, for the most part, only by the slow accumulation of occasional bits of evidence, obtained largely by what may be termed accident, that the life-histories of these terrible pests have been brought to their present more or less incomplete state. Pending further observations existing gaps are filled in by more or less probable conjecture.

Oxyuris vermicularis, it is well known, inhabits the large intestine of man, occurring not seldom in thousands, smaller numbers being found in a very large percentage indeed of the subjects for post mortem examination. The worm is not confined to any particular period of life. Though most common in children, scarcely any of whom remain between the ages of two and eight completely free from Oxyuris, it is not less than frequent in older people, even including those of extremely advanced age. Its constant presence and the suffering thereby frequently caused, especially in children, where it often leads to extreme nervousness and irritability to say nothing of its annoying evening attacks, has led to much investigation which is recorded in a literature so abundant as to be equalled by that of but few animal species. Where investigation has failed to throw sufficient light, speculation has stepped in and rendered good service in the labour of completing a rational life-history.

It has been found that both sexes of this parasite inhabit the human intestine in about equal numbers.* They reach there their full size, feeding upon the contents of the intestine, and the females produce and lay eggs which may be found in almost every particle of the excrement of persons suffering from an attack of Oxyuris. The adult females have a tendency to wander to and outside of the anus, especially at evening, probably for the purpose of laying their eggs. It is these females which cause the itching sensation peculiar to attacks of "pinworms." If the offending worms be artificially removed they are invariably found to be adult females having their sexual organs distended with eggs which they begin to deposit immediately on exposure to the outer air.

It was when we came to the fate of the eggs that uncertainty prevailed. It was held on the one hand that the eggs hatched and developed only in the large intestine, and the entire cycle of life thus completed in the birth-place. Holding this view, Vix contended that a person once infected with Oxyuris might remain so indefinitely. On the other hand, and as we shall see with better reason, it was contended that the eggs hatched normally only on being introduced into the human stomach.

Those holding the first view based their belief on the occurrence side by side in the same intestine of all the stages in the development—eggs, larvæ, and adults. At first sight this seems plausible enough, but further thought shows that the same facts support the second view to an extent almost if not quite equal.

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* Leuckart and many others state that the females are more abundant than the males, and Leuckart gives as the result of his investigations the ratio 9:1. Devaine however believes the males to be as abundant as the females and I will add a case supporting his view. I took the entire mass passed from thoroughly purging a case of Oxyuris and poured it into hot corrosive sublimate solution, shook immediately and violently, and then examined the whole precipitate most carefully under a powerful magnifying glass, with the best illumination. Being practised in searching for much smaller free-living Nematodes, treated in a similar manner, I am confident that none or almost none escaped the scrutiny. The result was 49 males and 52 females.

Furthermore, it was possible to adduce in favour of the second view and against the first the following weighty considerations :—

1. The eggs found in fæces are generally in the first stages of development.

2. Such a mode of development as is supposed in the first view would constitute an exception to the general rule for the development of all entozoa, which is that the eggs or larvæ pass out to develop, to some extent at least, outside, and then to find, after a more or less chequered career in the course of which they may live for a time in a species different from that inhabited by their adults, a new host of the original kind.

3. Investigators who were generally free from Oxyuris having swallowed its eggs passed nearly mature worms after about two weeks.*

4. The larvæ have been found in the duodenum and small intestines.†

5. Life-histories consonant with this second view have been more or less perfectly established for some of the other species of the genus Oxyuris.‡

In fact these considerations have been thought by some to be sufficiently weighty to warrant the assertion as an established fact that the eggs of Oxyuris vermicularis first hatch on being introduced into the human stomach, and that the larvæ on reaching the large intestine remain there to maturity. Such an assertion is, however, not warranted by the above enumerated considerations.

This incomplete state of our knowledge concerning the development of the Oxyuris of man led me to perform some experiments. I placed twelve eggs of Oxyuris vermicularis in a suction capsule,§ sealed and partially exhausted of its air, and

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* Leuckart, "Parasiten d. Menschen."

† Zenker, "Verhandl. der physik. med. Soc. zu Erlangen," 1872.

‡ Balfour, "Comp. Embryology," Vol. I.

§ For description see "Two new instruments for biologists." Cobb, Proceed. of Linn. Soc. of N.S.W., 1890, p. 157.

swallowed it. This capsule for some reason I never recovered, and this fact led me to abstain from repeating the experiment until it became certain that no evil effects resulted. After waiting about a year I became convinced that in the disagreeable search for the capsule I must have overlooked it. In my second experiment therefore I took precautions to insure an early recovery. Obtaining at last a fresh supply of eggs, I swallowed another similarly prepared capsule after having partaken of a liquid dinner. This was at 7 p.m. At 2 a.m., I took a dose of castor oil, and at 7 a.m., recovered the capsule by means of a long handled paint brush and a sieve whose meshes were just small enough to intercept the capsule. On breaking the capsule I found the embryos hatched and in active motion. The eggs used in this experiment were *freshly laid* and contained embryos in the so-called tadpole stage. The results of this experiment led me to make a third, in which I used a large number of eggs containing fully developed and, when warmed, actively moving larvæ. This third capsule was swallowed at $10\frac{1}{2}$ p.m., and recovered, by purging, at a little before 4 a.m. It remained in the alimentary canal in all less than six hours. On opening the capsule on a warm stage I received a large number of actively moving larvæ which I at once killed, a part with hot solution of corrosive sublimate and the remainder with $\frac{1}{10}$ % osmic acid and brought respectively into Canada balsam and glycerine by means of the differentiator.* The results of experiments two and three I will now detail in full.

Experiment II.

Nearly all the eggs used (12-13) hatched. Most of them had undergone some development, more in fact than the remaining eggs out of the same lot which lay meanwhile in the dead and dry female worm, but not so much as might have been expected. The

* For description see "Two new instruments for biologists," Cobb l.c. Also British Association for the Advancement of Science, "Report (1889) on the Zoological Station at Naples."

largest of the hatched larvæ did not much exceed 0·11 mm., while the smallest had hardly developed beyond the tadpole stage at which they were inserted. Thus it will be seen that it is not necessary that the eggs of Oxyuris vermicularis should undergo any considerable development outside the body of its host, though normally they do so without a doubt. What would have been the fate of these smallest larvæ no one can tell. I believe they would if left free in the alimentary canal have lived and developed. The cuticula was already well-formed, and, with the very highest powers, visibly transversely striated.

A comparison of the unhatched specimens with the empty shells proved that the embryos escape from the egg in a uniform and definite way. I already knew of the existence of pores in the shell of the eggs of this species of Oxyuris. I discovered them while attempting to rear the larvæ from eggs kept in artificial digestive fluids,* in which attempt I failed. I found, however, that after about twenty-four hours at body temperature the artificial digestive fluids brought to view distinct pores in various parts of the shell. The distribution of these pores seemed to me at the time quite irregular, and I never saw more than two or three in close proximity. I overlooked entirely a phenomenon which was first brought to my notice by experiment two here described, namely, *the existence of a distinct area* (Pl. VIII, Fig. 1), *where these pores are very numerous and which becomes the place of exit of the embryo.* I was first made aware of this fact on comparing with each other the empty shells from which embryos had made a normal exit. These empty shells were without exception ruptured at the same place. To locate this place accurately it will be necessary to describe the egg. The eggs of most species of Oxyuris are more or less irregularly spindle-shaped. The irregularity consists in a curvature of the long axis in the dorso-ventral plane of the future embryo. Furthermore, the two rounded ends of the egg are dissimilar, the anterior end, speaking again from the position of the future embryo, being more pointed than the posterior. When therefore the egg is viewed in profile, and this

* Lactopeptine and other proprietary preparations.

is the view generally obtained under the microscope, it presents a nearly straight ventral and a decidedly arcuate dorsal contour, the anterior end being evident from its pointedness. At the anterior end, then, and on the dorsal surface of the shell of the egg of Oxyuris vermicularis is a circular area whose structure is not uniform with that of the remainder of the shell, and which is destined to give way for the passage of the embryo on its issuing from the egg (Pl. VIII, Fig. 1). Now that I have demonstrated its existence I have no difficulty in seeing this structure at any stage after the formation of the shell, though *through the action of the gastric fluids it very soon becomes much more apparent* as a porous area. Whether the pores exist previous to the action of the gastric fluid or are a result of its action I cannot positively state. I believe, however, that something like the former is the case and that the porosity becomes more apparent as the stomach fluids continue to dissolve this part of the shell, which ultimately becomes so weak that the movements of the embryo cause it to give way.

The embryo seems to issue uniformly tail first.* A fully formed embryo is doubled upon itself twice, the posterior bend being situated at the anterior end of the egg. It is this posterior bend that issues first, followed by the tail, and finally the head.

Whether the above described area will be found to bear any relation to the ovarian history of the eggs and the entrance of the spermatozoa remains to be seen. It seems to me not improbable that a connection may exist.

Experiment III.

All the numerous eggs used in this experiment contained fully developed embryos, *nearly all* of which became hatched inside of six hours, proof enough that *quick advantage is taken by* Oxyuris vermicularis *of a chance to establish itself in the human alimentary canal.* A goodly amount of gastric fluid entered the capsule, and the results must be regarded as quite

* I speak here from later observations.

normal. The shells did not become dissolved, though they all became somewhat rounder (*i.e.*, wider and shorter) and thinner. In neither of the experiments two and three did I notice the pores scattered here and there over the whole surface of the egg as was the case when I subjected some eggs to the action of artificially prepared digestive fluids.*

The larvæ are of the form shown in Fig. 2. The average length is 0·155 mm.; the bottom of the mouth cavity or pharynx is distant 1%, the nerve-ring 12·4%, the posterior end of the œsophagus 33·1%, and the anus 78·4% of the length of the animal from the anterior extremity; the diameter opposite the base of the pharynx is equal to 3%, opposite the nerve-ring to 6·6%, opposite the posterior end of the œsophagus to 6·8%, opposite the middle of the body to 5·7%, and at the anus to 3·2% of the entire length of the animal, dimensions which may be conveniently expressed by the formula

$$\frac{1 \qquad 12{\cdot}4 \qquad 33{\cdot}1 \qquad \text{M} \qquad 78{\cdot}4}{3{\cdot} \qquad 6{\cdot}6 \qquad 6{\cdot}8 \qquad 5{\cdot}7 \qquad 3{\cdot}2}\ {\cdot}115$$

in which the figures above the line represent lengths and those below the line represent *corresponding* diameters, expressed in such a manner that the unit of measurement is *one per cent. of the entire length.*† The *porus excretorius* is situated 31·2 % of the length from the anterior extremity. The head is rounded, the tail conoid. I believe that the sexes are already distinguishable and that Fig. 2 represents a male. The females diminish in diameter very uniformly from the œsophagus backward, while the males have the tail contrasted by a sudden decrease in diameter in the preanal region as is shown in the figure.*

* The eggs used in those experiments were obtained in Germany, where I was then residing, while those for experiments two and three here described were obtained from Australian subjects, facts which may possibly account for the difference.

† A method of expressing the dimensions of Nematode worms which I have found extremely convenient, the formula recording in itself sometimes all that is necessary to characterize the species.

* If this distinction between the sexes holds good, it follows as a corollary, according to my observations, that the sexes are born in about equal numbers. I made no count, but no great inequality could have existed without my noticing it.

Cuticula.

Concerning the cuticula I have little to say beyond stating that it is composed of three layers and exhibits under the highest magnification fine transverse striæ. There is no indication of the future cuticular growth at the head unless two large cells, one placed dorsally and the other ventrally, be so considered, and I am doubtful if that can be done. These cells are pointed out at *d*, *d*, Fig. 2. On the other hand the wings are to be distinctly seen and apparently extend from one end of the larva to the other.

The Alimentary Canal.

The mouth is as yet unprovided with distinct lips. The saucer-shaped mouth-cavity leads to an œsophagus which is most appropriately likened to that prevailing in the genus R h a b d i t i s, that is to say the anterior half, which is swollen at its posterior extremity, is connected by a narrow passage with an elongated-ellipsoidal posterior bulb. This bulb sometimes does and sometimes does not show traces of the future valvular apparatus. The swelling at the posterior extremity of the anterior half of the œsophagus seems to me to have the signification of a bulb, but while the posterior bulb is composed of numerous small cells, this median bulb, as I will term it, is composed of about six large elongated cells whose long axes lie in the direction of the œsophagus. In the remaining parts of the œsophagus the cells present large elongated nuclei. The intestine, at first narrow, gradually widens to the middle of the body, where it has a diameter one-third as great as that of the body itself, and then continues with a uniform width until near the anus, where it presents a broad constriction similar to that figured by Galeb* for the larvæ of some species of O x y u r i s parasitic in insects. I do not think that this constriction corresponds to the beginning of the rectum. I am not certain what its signification is. I have observed an

* "Organisation et développemente des Oxyuridés." Arch. d. Zool. Exp. VII. 1878.

exactly similar constriction in the intestine of the larvæ of Rhabdonema nigro-venosum. One is reminded of the peculiar formation of the posterior part of the intestine in Dorylaimus, without however receiving thereby any elucidation of the present structure. What I regard as the true rectum is narrow and has a length not exceeding that of the anal diameter. There seem to be several one-celled glands around the rectum. Where they empty I cannot say. In the larvæ of Oxyuris obvelata, the Oxyuris of rats and mice, I have seen corresponding one-celled glands and am certain that they empty by long narrow ducts *into the rectum at its middle.*

Muscular System.

Observations on the muscles were unsatisfactory. The muscle-cells were distinctly visible and the system seemed to be that of the Nematodes called by Schneider* Polymyarier. The adult Oxyuris belongs to his Meromyarier.

Reproductive Organs.

The cells destined to give rise to the reproductive organs lie in the ventral part of the body cavity somewhat behind the œsophagus. (s, Fig. 2.)

Jugular Cells.

Under this non-committing name I call attention to some cell-masses in the neck of the larva. I think there are three such masses. They may have some connection with the nervous system. (j, Fig. 2.)

Nervous System.

The nerve-ring is not easily discovered. From a large number of observations, however, I have been enabled to determine its position, as will be seen by the figure and the formula. It encircles the œsophagus considerably in front of the median bulb, and, like the nerve-ring in the adult worm, is not in the least oblique. (Fig. 2, n.)

* "Monographie der Nematoden," &c.

Excretory System.

I have reserved this system until the last because I have the most to say concerning it. It consists simply of a one-celled gland emptying ventrally opposite the posterior bulb of the œsophagus by means of a short and narrow duct. (Fig. 2, v.) Its form strongly reminds one of the ventral excretory organ as it exists in a large number of free-living Nematode genera. Its position, however, alters rapidly with the growth of the animal, becoming situated in the very first stages of larval growth quite behind the œsophagus. Its later history I do not know from observations on Oxyuris vermicularis, but in Oxyuris obvelata it is as follows: It exists at first in the form here shown for vermicularis. It rapidly increases in size posteriorly and becomes bifurcated. Each of the branches moves to the adjacent lateral region and becomes attached to the lateral field thereof, continuing all the while to increase posteriorly. (Figs. 3, 4, 5.) It thus gives rise to the two lateral ducts which are so often described in Nematodes as uniting and emptying ventrally through the *porus excretorius.*

It seems to me that much confusion with regard to the excretory system of Nematodes has arisen in a very natural way. The oft-mentioned lateral ducts or lateral vessels were first discovered in some of the larger parasitic forms (Ascaris lumbricoides, &c.), and were afterwards found to exist in many parasitic species, being sometimes imbedded in the substance of the lateral fields. The nature of these vessels was at first uncertain. They were held by some naturalists to constitute a circulatory system, but by others were regarded as part of a water-vascular system. The fact that these vessels almost universally emptied through a single ventral opening of small dimensions gradually led to the opinion, solely on morphological grounds however, that the two vessels were excretory in their function. The small ventral pore was given the name of *porus excretorius.* The connection with the lateral fields led however to a very natural morphological error, namely the opinion that

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the lateral vessels constituted a fundamental part of the lateral fields, the latter coming therefore to be regarded as perhaps also excretory in their function.

Several facts have long since come to light which render this position untenable. In the first place it was found that the lateral vessels were not always present on both sides. The number of species possessing but one lateral vessel has gradually increased until, in the important genus Ascaris at least, two vessels can hardly be said to be the rule. When, however, only one lateral field has a vessel connected with it the other lateral field remains, except for the disappearance of the vessel, essentially unaltered, something not to be expected if the connection between vessel and field was in any way intimate. In the second place submedian fields exist, hardly to be distinguished in structure from the lateral fields, and in connection with these submedian fields no vessels have ever been seen. In the third place the connection between the vessels and the fields though in some cases apparently intimate is in many cases manifestly slight.

Still when it became gradually established through the researches of Eberth, Bastian, Bütschli, Von Linstow and De Man that the existence of a unicellular gland emptying through a ventral pore was of very general occurrence among free-living Nematodes, so firmly had the idea of lateral vessels in connection with lateral fields taken hold that the homology of the newly discovered unicellular organ with the long known lateral vessels was not recognized and it remains to day very incompletely acknowledged.

The homology is I believe complete. Once set up a disconnection between the lateral fields and the lateral vessels and the homology is much more easily recognized. Reasons for holding the connection which does actually exist as of no great significance have been enumerated above. This connection may have, nay probably has, been brought about quite mechanically. The Nematode worm from the beginning undulates its body in a dorso-ventral plane and this movement is an important factor in the development and position of the organs, and to it is probably due the position of the long lateral vessels of the large parasitic species. The connection seldom reaches that state in which it became early known in Ascaris lumbricoides, where the vessels are actually embedded in the substance of the fields. More often the vessels are simply attached to the fields by connective tissue, in which case all cross-sections emphasize the fact that the connection is mechanically wrought and of no deep significance. This is strikingly the case for instance in sections of two species of Ascaris whose structure is well known to me, Ascaris Kükenthalii from whale and Ascaris bulbosa from seal of the Arctic Ocean.*

Granted that the connection between the lateral fields and the lateral vessels, intimate as it sometimes seems, is as it were accidental, we have, in order to prove the homology of the vessels with the one-celled ventral organ of the free-living Nematodes, only to reconcile the duplex nature of the vessels with the more simple nature of the unicellular gland. This can be very conclusively done. In the first place it is to be observed that it remains to be seen whether a duplex form of this organ does not occur among free-living forms. I think there is reason to believe that it exists there and is perhaps even not uncommon. In the second place it is to be observed that in the large parasitic worms the organ is often, to say the least, single. In the third place the large size and consequent different shape of the organ in the parasitic Nematodes simply accords with their larger size. Should a typical free-living Nematode three to four inches long ever be discovered I should be surprised to learn that the ventral gland was a unicellular organ of the form familiar in Oncholaimus and other free-living genera. In the fourth place, and here we return to our Oxyuris larvæ, it seems that the development of the organ in the parasitic species is such as to set the matter quite at rest, if we trust ontogenetic evidence. The full grown excretory organ in the genus Oxyuris is well known to consist of four vessels originating in a ventral ampulla and extending two forwards and

* Cobb, "Beiträge z. Anatomie und Ontogenie d. Nematoden," Jenaische Zeitschrift, XXIII. Bd. N.F. XVI.; also Archiv für Naturgeschichte, I. B., 2 Heft, 1889.

two backwards, along the lateral fields. But the young larvæ of Oxyuris vermicularis and obvelata, as I have shown, possess the organ in the form now so well known among free-living Nematodes. By increasing with the growth of the larvæ and becoming bifurcate the simple unicellular form gives rise to the larger, later and more complicated system of vessels.

I have dwelt at some length upon this matter because in the Nematode literature as a whole there lurks a suspicion that the two structures so often mentioned in the preceding paragraphs, the lateral vessels and the lateral fields, are in some way intimately connected with each other, and as a kind of corollary that the lateral fields may be excretory in their function, a suspicion which seems to me groundless. I will add that I have tested the lateral vessels of Ascaris lumbricoides, the large stomach-worm of man, to ascertain the nature of their contents, and have proved the presence of urea and sodium chloride, weighty evidence in favour of regarding the vessels as excretory organs. Until now the evidence supporting such a belief has been solely morphological. Schneider failed to find uric acid in the vessels of Ascaris marginata. I also failed to find uric acid in the vessels of A. lumbricoides, but should not deny its presence without first making further tests. I shall give the details concerning my tests and methods at another time, when I can accompany them by the results of further experiments now in progress.

Phylogenetic.

In three respects Oxyuris vermicularis seems to differ considerably from the majority of the species of its genus. These are, the peculiar structure of the head, the position of the nerve ring and the position of the *porus excretorius*. In all these respects, the larva stands nearer the average Oxyuris than does the adult, showing that in these particulars vermicularis is a departure from the type of the genus.

Does the structure of the larva of Oxyuris throw any light on the ancestry of the genus? A glance at Fig. 2 tempts one to hazard an answer in the affirmative. The striking resemblance existing between the adults of the two genera Oxyuris and Rhabditis* have been often remarked. So long as the adults only are considered the resemblances are open to either of two interpretations.

1. The resemblances may be due to a close genetic relationship.
2. They may be due to the reaction of the environment, which is to some extent similar for the two genera.

In the latter case a close genetic relationship is supposed not to exist, and no very striking resemblance would be expected to obtain at any period of life on which the selective influence of the environment had not been exerted. The embryonic life is probably that on which the environment would have least influence. Consequently if the embryos of Rhabditis and Oxyuris resemble each other, or if the similarity between the average mature form of either of these genera and the embryos of the other be greater than that between the adults of the two genera, we should be justified in preferring the first interpretation. In either case we naturally appeal to the ontogenetic evidence before us. If the first interpretation be the true one, a study of the development would betray the relationship, which should be one of the following :—

1. The one genus a direct or indirect derivative from the other.
2. Both genera separate derivatives from an older form.

In the latter case the successive developmental phenomena of the two forms should diverge. In the former case, the natural supposition being that Oxyuris is the younger group, the larvæ of Oxyuris should have greater affinity with Rhabditis than have its adults.

Now this seems to be the case. Our figure represents an œsophagus for instance which is much more Rhabditis-like than the œsophagus of the adult Oxyuris. The median swelling containing the large cells must, I think, be interpreted as a bulb, and it is at this point that a bulb or something like

* In the discussion which follows I have in mind also the allied genera Diplogaster, Anguillula, Cephalobus, &c.

it is usual in Rhabditis. The pharynx is open, though it is already less like the pharynx of Rhabditis than it was during the tadpole stage, when it was deeper and cylindroid, constituting one of the striking features of the embryo. The nerve-ring has not the position usual in Rhabditis (behind the median swelling), but approaches it much more nearly than does that of the adult Oxyuris. Finally, the *difference between the sexes which already exists in the larval state* * points to a *deep-rooted* tendency toward an early degeneration of the male tail, something which finds a ready explanation in supposing the sexes to have been unlike in the ancestors of Oxyuris. Now the sexes are more unlike in Rhabditis than in most free-living genera, but its *larvæ* do *not* show so early or so striking a sexual differentiation as is to be seen in Oxyuris.

If these considerations are as weighty as they seem (to me) to be, we are justified in deriving Oxyuris directly from some part of the group of Rhabditis-like free-living forms.

Contagion.

The world-wide common occurrence of Oxyuris vermicularis points to an efficient method of distribution. The method is simplicity itself. The 20,000 eggs which at a moderate calculation each adult female contains are laid either in the large intestine to pass out with the excrement or are laid just outside the anus. They become distributed over the person, clothing, bed-clothing and other articles of furniture, of the infected, and in excrement are sown broadcast over cultivated lands. They then find their way to the mouth, mostly by way of the hands, less commonly by other agencies, are swallowed, hatch promptly in the stomach,† and on reaching their proper habitat, the colon, are prepared to hold their place there until maturity.

The abundance of the eggs about dwellings, &c., is difficult to

* True also of the larvæ of some Oxyurids inhabiting insects. See Galeb, l.c.

† This link in the history was first established by the experiments just described.

overstate, and is easily illustrated by a calculation. Reckoning fifty female worms to the individual, an average which I am certain is exceeded in many localities, we have for a population of 250,000, the enormous number of two hundred and fifty thousand million eggs, which if distributed evenly over twenty square miles would furnish *four to five hundred eggs to the square foot.* They are, however, not distributed uniformly. They are most abundant in the fæces and on the persons of the infected—*i.e.*, about the anus, under the nails and on the clothing. Thence we may trace them in ever decreasing abundance through wash- and bathing-water, &c,, to a more general distribution,—facts so well-known that I need only state them.

Whatever moves and comes in contact with the eggs is likely to transport them from place to place. Animals, especially flies,† currents of water, currents of air carrying dust, all become agencies in disseminating these minute eggs.

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† On another occasion I have written concerning flies as follows :—

" Nor are these latter agencies such remote causes as might at first be supposed. It is well known that birds are great travellers, but at certain seasons they are outdone by flies. They are, no doubt, in Sydney to-day hundreds of flies that were born and brought up in Melbourne. This is no rash statement. I know of some that arrived in the Iberia ; and they arrive by every train from points more or less distant. I have had an individual fly under observation for a hundred miles (Springfield to Boston, Mass.), and often for shorter distances. Some flies shut into the waggon with me one evening in Dresden arrived safely in Berlin at midnight, and I have no doubt flew out when the cushions were dusted next morning. Steamers several days at sea generally lose these unwelcome passengers. but I have seen flies on a vessel in mid-ocean, thousands of miles from her last port.

" But, aside from being conveyed by artificial agencies, these little beasts are no mean navigators of the air. They can fly as fast as a horse can trot, and that for long distances. I have known them to arrive promptly at a vessel anchored above a mile from any object that would afford an alighting place. I have set loose numbers of marked flies, and shortly afterwards recaptured some of them at my neighbours' houses.

" Do they carry typhoid germs ? Doubtless. Darwin found 537 seeds to have existed in three teaspoonfuls of ordinary pond-mud taken at random, and suggested that hastily flushed water-birds carrying such mud on their feet must become distributors of such seeds. A fly is just as capable of carrying disease germs as a duck of carrying Juncus seeds.

" I can advance no instance in which flies have been known to carry typhoid germs, but that they carry about on their feet much larger objects, namely, the spores of common mould, I have repeatedly observed. The mould-spores are not large objects, are in fact invisible. Still a sufficiently

To exclude O x y u r i s it is only necessary to exclude its eggs. Unfortunately the minuteness and abundance of these latter render their complete exclusion difficult. They gain access easily by means of such vehicles as air, food and drink—how easily will be best inferred by glancing at the ensuing list of possibilities.

The eggs arrive at the hands

- *If directly, then from the person of the infected (hand-shaking, &c.)*
- *If indirectly, then*
  - *By handling soiled clothing.*
  - *By usage in common with the infected of the same articles (household and office furniture, public conveyances, &c., &c.).*

The eggs arrive in the mouth

- *From putting the fingers in the mouth.*
- *From biting the nails.*
- *From putting handled articles between the lips or teeth (pens, pencils, pins, money, stamps, gloves and a hundred other things).*
- *From washing the face and hands in the same water.*
- *From use of any of the numerous edibles, &c., which come from the market after indiscriminate handling and exposure and are then eaten uncooked. Especially to be mentioned are*
  - *Butter.*

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patient and skilful person can isolate one and plant it as accurately as a gardener plants a pumpkin seed. It was while making some experiments of this kind that I caused a fly to walk over a glass sprinkled with mould-spores and then over some freshly prepared gelatine in a dish near by. Next day the fly's footprints could be read on the gelatine in visible mould. At each step the little creature had deposited spores which during the night had germinated. Microscopical examination revealed spores on the fly's feet.

"That the house-fly is an agent well calculated to promptly transfer the dreaded fever germs to our food and drink is only too clear. It frequents for the purpose of laying its eggs the very places (water-closets, &c.) where the germs are most likely to be found. That it returns promptly from thence to feed upon fruit and other food in too many kitchens, in too many shops, and on too many dinner-tables requires no proof."

*Confectionery.**
Vegetables and fruit eaten raw.
Bread, cakes and pastry.
Cigars and cigarettes.
From table utensils (napkins, toothpicks, &c.).
From drinks.
From breathing dusty air (clouds of dust on the streets, dusty air when clothing or carpets are dusted).

EXPLANATION OF PLATE.

a.—Anus.
b.—Posterior bulb of the œsophagus.
c.—Constriction in intestine.
d.—Two large cells at the head.
e.—Ampulla.
f.—Margin of the lateral field.
i.—Intestine.
j.—Jugular cells.
l.—Muscle cells.
m.—Median bulb.
n.—Nerve-ring.
o.—Mouth.
p.—Porous area on the egg.
s.—Sexual organs.
t.—Cuticula.
v.—Ventral gland,

Fig. 1.—Anterior extremity of the egg of Oxyuris vermicularis in optical section, showing the position of the porous area. × 1300.

Fig. 2.—Larva of Oxyuris vermicularis, not yet six hours old, hatched under normal conditions in the human stomach. × 900.

Figs. 3, 4, and 5.—Different stages in the development of the excretory organ of Oxyuris obvelata. Highly magnified. Fig. 5 shows the gland bifurcated.

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* There is a common belief that confectionery eaten freely is productive of thread-worms. Confectionery being often more or less sticky is very well adapted to carry the eggs, but the worms which become troublesome soon after its consumption are not a direct but an *indirect* result. Eaten in undue quantity sweets cause acidity from which the worms flee, soon making their appearance near the anus and becoming troublesome. They are worms that were already present,—were not imported with the sweets.